

# **Report as of FY2008 for 2008PA89B: "Impact of infiltrating runoff on groundwater recharge quality"**

## **Publications**

Project 2008PA89B has resulted in no reported publications as of FY2008.

## **Report Follows**

## PRINCIPAL FINDINGS AND SIGNIFICANCE

This project provided seed funding to start a long-term research endeavor exploring the impact of infiltrating storm-water runoff on the quality of ground water. The goal of this work was to quantitate pollutant loading to ground water beneath stormwater detention basins. During the project period, we began our analyses of infiltration rates and pollutant removal with depth beneath the surface, both in laboratory experiments and in the field. In addition, examined soil amendments which may be used as preferential sorbents for infiltrating contaminants and developed a spreadsheet model of ground-water infiltration following rainfall events. As managers prioritize resources for alternative water management practice and encourage aquifer recharge, it is important to identify regions of aquifer vulnerability to surface-derived contaminants and to develop best management practices for protecting ground water. To do this, a thorough understanding of pollutant transport during infiltration is required. It is our goal to optimize ground-water recharge management, preserving ground-water quality and quantity in urban and urbanizing areas of Pennsylvania.

### Field measurements of ground-water recharge quality:

Suction lysimeters were installed at two depths beneath land surface in a stormwater detention basin in Philadelphia county to collect water samples during rainfall infiltration events. A great deal of heterogeneity was observed in the subsurface, and spatial analyses of surface infiltration rate measurements collected using a Cornell sprinkle infiltrometer are currently underway. A schematic of field instrumentation is provided in Figure 1. During rainfall events, grab samples are collected from ponded water in the detention basins and the pump to the suction lysimeters is turned on to collect water samples as the wetting front infiltrates through the unsaturated zone. Water samples are returned to lab and analyzed for pH, TSS, total phosphorous, total nitrogen, copper, lead, chromium, total coliforms and *E. coli*. Preliminary results suggest slight removal of TSS with depth. Experiments continue and field instrumentation of a similar detention basin in the Valley Creek Watershed is planned for Summer 2009.

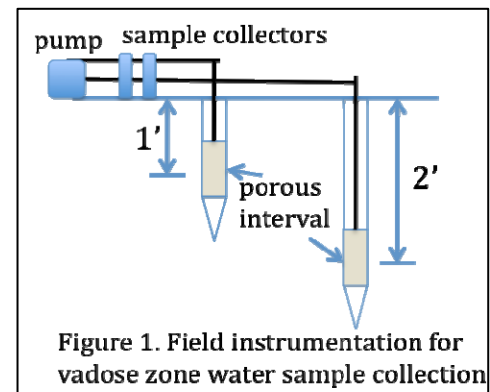


Figure 1. Field instrumentation for vadose zone water sample collection

### Development of a surface-water infiltration model:

Localized recharge to ground water induced by infiltration from detention basins is a significant mechanism by which stormwater pollutants may be introduced to underlying ground-water supplies. The infiltration rate determines the rate at which surface water contaminants reach the underlying ground-water table. The Joint Green-Ampt infiltration was developed by combining two existing infiltration models into a fully explicit model. A comparison of the joint approach against an implicit model confirms that the accuracy of the joint model is sufficient for use. The fully explicit equations make it easy to perform calculations in a spreadsheet environment. The model can be used for a constant rainfall event in uniform soil. As part of this work, we developed a fully explicit spreadsheet model for estimating infiltration; we are currently updating this model to include contaminant transport and removal. The model is described as follows:

When  $r < K_s$ ,  $q = r$   $I = rt$

When  $r > K_s$  and  $t < t_0$ ,  $q = r$   $I = rt$

When  $r > K_s$  and  $t > t_0$ ,

$$q = K_s \left( \frac{\sqrt{2}}{2} \tau^{-1/2} + \frac{2}{3} - \frac{\sqrt{2}}{6} \tau^{1/2} + \frac{1-\sqrt{2}}{3} \tau \right)$$

$$I = K_s \left\{ \left( 1 - \frac{\sqrt{2}}{3} \right) t + \frac{\sqrt{2}}{3} \sqrt{\chi t + t^2} + \left( \frac{\sqrt{2}}{3} - 1 \right) \chi [\ln(t + \chi) - \ln \chi] + \frac{\sqrt{2}}{3} \chi \left[ \ln \left( t + \frac{\chi}{2} + \sqrt{\chi t + t^2} \right) - \ln(\chi / 2) \right] \right\}$$

$$\text{With } \chi = \frac{(h_s - h_f)(\theta_s - \theta_0)}{K_s}$$

$$\tau = \frac{t}{t + \chi}$$

$$t_0 = \frac{-K_s h_f (\theta_s - \theta_0)}{r(r - K_s)}$$

Where

$q$ : surface infiltration rate (cm/h);  $I$ : Cumulative infiltration (cm),

$r$ : constant water application rate at the surface (cm/h);

$t$ : time (h);  $K_s$ : saturated hydraulic conductivity (cm/h);

$\theta_s$ : saturated volumetric water content (cm<sup>3</sup>/cm<sup>3</sup>);

$\theta_0$ : initial volumetric water content (cm<sup>3</sup>/cm<sup>3</sup>);

$h_f$ : capillary pressure head (< 0) at the wetting front (cm);

$h_s$ : ponding depth or capillary pressure head at the surface (cm);

$t_0$ : time when surface saturation occurs( h)



**Figure 2.**  
Laboratory  
infiltration  
columns.

#### Laboratory studies of infiltration and pollutant removal:

Laboratory columns were designed and constructed to simulate surface recharge during infiltration of ponded water (Figure 2). Transient pore water pressures were measured using tensiometers evenly dispersed along the length of the column. Water samples were collected via syringes inserted into sampling ports along the length of the column. Synthetic stormwater amended with microorganisms was ponded at the top of the column and the infiltration front was measured. Modest improvements to bacterial removal rates have been observed when a layer of manganese-dioxide sand was packed in the column as a sorptive amendment.

## PHOTOS OF PROJECT



Drexel University graduate student Laura Klinger installing suction lysimeters to measure ground-water quality versus depth beneath a Philadelphia stormwater detention basin.



Field installation of suction lysimeters for ground-water sampling beneath a Philadelphia detention basin.



Field collection of stormwater infiltrating through the subsurface in a detention basin.